3.2.2. Controls and Displays

3.2.2.1. Purpose

The purpose of this test is to assess the suitability and utility of the navigation controls and displays for the assigned mission as an interface between the operator and the navigation system.

3.2.2.2. General[8]

As good as many new systems are at determining the position, rates and orientation of the aircraft and in providing recommended steering information, they have failed if the operator is not presented with a usable display of navigation parameters or if the operator is not given adequate controls to operate the system. The controls and displays must be usable in every conceivable flight regime, ambient lighting condition, weather condition, and by aviators with the range of anthropometric measurements for which the system was designed to operate. For the modern fighter or attack airplane, this is usually all weather, day or night, around +9 to -4 gs, for the 3 to 98 percentile groups, and in a realistic tactical environment filled with urgent decisions demanding the aviator's attention. The controls and display should require an absolute minimum of operator input or interpretation and the information imparted and required from the operator should be a minimum and precisely what the aviator needs to execute the current phase of flight. The requirement to tailor the information provided to the phase of flight is particularly important for a navigation system.

Controls should be easily manipulated wearing the proper flight clothing. The range of control (both the physical range of movement of the knob, dial, lever, etc. and the range of effect that the control has upon the navigation system) and sensitivity should be compatible with the expected flight regime. Controls that require manipulation while airborne should be reachable from the DEP, particularly if they must be activated in a combat environment. As an example, the controls necessary to perform a visual position update must be reachable while performing high g evasive maneuvers ingressing to a target and while maintaining a body position ready for safe ejection. The operative sense must be correct. This means that the direction of activation should conform to the standards of common sense (turn the knob to the right to turn on the system) and to the standards set in references 15 and 16 (which for the most part merely put on paper the standards of common sense). The operation of the controls should be clear, requiring a minimum of operator concentration and attention. This leaves the operator free to make tactical decisions.

The controls should also be placed in logical functional groups, reducing the area of scan required to check the navigation system set up. The navigation system controls should be integrated well into the cockpit. This means that the navigation system controls should operate harmoniously with the other controls within the cockpit and without hindering the simultaneous operation of other airplane systems. Integration must be evaluated during a mission relatable workload and while simultaneously operating all the other airplane systems. This is important since navigating should take a minimum of operator concentration and time, leaving the operator free to perform other tasks, such as selecting targets and evading surface to air missiles.

Lastly, the controls should provide good tactile feedback. For example, detents should provide the proper amount of "click" and all the knobs shouldn't feel exactly alike when reaching for a navigation control with eyes on the radar scope. Applying a little common sense and manipulating the controls in a mission relatable environment usually uncovers most of the control human factors violations.

Many modern aircraft have a large number of the avionics controls included in the HOTAS format, allowing manipulation without releasing the throttle and stick. These implementations have their own human factors challenges. Typical problems include the mounting of too many controls on the available area, appropriate control sensitivity across broad height conditions and tactile feedback considerations.

The navigation displays should be clearly visible from the DEP in bright daylight as well as complete darkness. In bright daylight, the display must be

[8] For an introduction into controls and displays human factors, see references 20, 54 and 73.

usable under all conditions of glare including sunlight directly over the operator's shoulder onto the display (a particularly serious problem for most displays). In the dark, the display should not be so bright that it distracts the operator or affects his night vision. A good range of brightness control that integrates harmoniously with the rest of the cockpit is required. In many cases, navigation information is integrated into other tactical displays. Heading markers, course, steering, range and time to go to waypoints etc. are often integrated into HUD and radar displays. The navigation information must be harmoniously integrated into these displays providing clear and concise navigation cues without degrading the other uses of the displays.

The display must refresh itself quick enough so that the symbology and alphanumerics present an even and continuous display without noticeable flicker. Analog displays and digital representations of analog displays such as compass cards, ownship on a geostable tactical display etc. should update smoothly as the simulated compass card rotates or the own aircraft symbol transits across the background. Alphanumerics must be clear and legible. The messages should be short and easily understood without excessive coding or operator interpretation. The information displayed to the operator, including symbols and alphanumerics, must be sufficient for the current phase of flight while at the same time not overloading the operator with information. This usually requires tailoring the display to the specific attack mode/mission/phase of flight, that is currently being used. The display should be assessed for the information load in a mission relatable scenario to determine its utility as an aid in the combat environment as well as in normal Instrument Flight Rules (IFR) navigation.

It is unlikely that a display compatible in size, weight, power and cooling requirements with a tactical airplane will be built in the near future that has too large of a usable display face. Thus, the display should be evaluated for size in a relatable mission environment, accounting for this element of realism. The display should be positioned in a location suitable for the mission. As an example, the course to target cursor, range/time to target etc., should be placed high in the cockpit, along with the radar and/or FLIR display, so that the operator can scan his sensors, recommended vectors and also visually search for the target. As with controls, display human factors problems typically surface by applying a little common sense while using the system in a mission relatable scenario.

3.2.2.3. Instrumentation

A tape measure and data cards are required for this test. A voice recorder is optional.

3.2.2.4. Data Required

Record qualitative comments, evaluator's anthropometric data and a list of personal flight gear worn. The location and type of the navigation information displays should be recorded for integrated systems that provide navigation information in several locations (HUD, radar display, Electro-Optic (EO) display, etc.). Legibility and readability of the navigation information in all display locations should be recorded. The location of the display from the DEP should be measured if a qualitative problem is noted. Reach length of the controls that are beyond the operator's reach while seated at the DEP during any mission relatable scenario should be recorded. The utility of the provided information and information load (Is too much information provided?) should be recorded during mission relatable scenarios.

3.2.2.5. Procedure

Find the DEP as outlined in the radar theory section. All ground and airborne tests should be performed while at the DEP and wearing a complete set of flight gear. Perform a system turn up on the ground outside of the hangar in a range of ambient lighting conditions (bright daylight to darkness which may be simulated using a canopy curtain). Manipulate all controls noting the factors discussed above. Measure the display usable area. Evaluate the display for the factors discussed above. Note and measure the position and reach length to all controls and displays that pose a visibility or reach problem while seated at the DEP. During airborne testing, manipulate the controls and make qualitative comments during mission relatable IFR navigation scenarios and mission relatable attacks and intercepts. Take particular note during extremes of ambient lighting for displays and during high g maneuvers for controls. Confirm the results of the ground checks for reach and visibility while airborne. Check the extremes of the control limits and sensitivity. Repeat the evaluation for each test flight.

3.2.2.6. Data Analysis and Presentation

Present a table of the operator's anthropometric data and the personal flight equipment worn during the tests. Present the seat position as the number of inches from the bottom of the seat travel. Relate the sensitivity of the controls to the tactical environment in which they are to be used. For example, a fighter's HUD brightness potentiometer knob may be too sensitive to use under moderate g or turbulence making it unusable during intercepts and ACM. Relate the accessibility, placement and grouping of the controls under mission relatable conditions. A navigation update selection must be readily accessible while maneuvering evasively inbound to a target and looking outside for surface to air missiles. Relate the control clarity, operative sense and tactile feedback to a multiple threat, combat scenario requiring the operator to make quick tactical decisions. If ambient lighting affects the display in any way, relate this to the limits of the possible combat environments. The displays should update smoothly as the aircraft maneuvers and transits.

Relate the information load presented the operator to the combat scenario discussed above and evaluate whether the needed information is present and whether too much information is cluttering the display. This information can include analog representations of navigation information, alphanumerics or symbols. This concept is closely related to the size of the display face usable area. A large scope can present more information without cluttering the display and requires less concentration to read and evaluate. The refresh rate should be related to the concentration required to interpret a jittery display. The display position should be evaluated for the type of information involved, the eye position required for using the display and the display position's effect upon scan.

3.2.2.7. Data Cards

Sample data cards are presented as cards 36 and 37.

CARD NUMBER ___

˙ . .ON SYSTEM CONTROLS

CLARITY OF OPERATION:

ACCESSIBILITY (MEASURE REQ ,.ACH IF A PROBLEM):

OPERATIVE SENSE:

ADJUSTMENT SENSITIVITY:

RANGE OF ADJUSTMENT:

TACTILE FEEDBACK:

FUNCTIONAL LOCATION/GROUPIN .J IF A PROBLEM):

INTEGRATION:

Card 36: Navigation System . ıta Card

CARD NUMBER ___

NAVIGATION SYSTEM DISPLAYS

[PERFORM IN BRIGHT DAY TO DARKNESS]

LIST THE LOCATION AND TYPE OF NAVIGATION INFORMATION:

LOCATION QUALITATIVE COMMENTS (MEASURE THE LOCATION IF A PROBLEM):

CONTRAST/BRIGHTNESS/GAIN CONTROLS (RANGE OF EFFECTIVENESS):

GLARE (BOTH FROM OUTSIDE AND INSIDE COCKPIT LIGHT SOURCES):

REFRESH RATE QUALITATIVE COMMENTS:

LOCATION OF THE SYMBOLOGY/ALPHANUMERICS UPON THE MULTIFUNCTION, INTEGRATED DISPLAYS:

INTERPRETATION OF SYMBOLOGY/ALPHANUMERICS:

INTEGRATION:

Card 37: Navigation System Displays Data Card